DOCUMENT RESUME

ED 095 852   IR 001 029

AUTHOR   Attala, Emile E.; Howard, James A.
TITLE   Field Evaluation of a Mini Learning Resource Aided
                Instruction System.
INSTITUTION   California Polytechnic State Univ., San Luis Obispo.;
                California Univ., Santa Barbara.
PUB DATE   74
NOTE   28p.

EDRS PRICE   MF-$0.75 HC-$1.85 PLUS POSTAGE
DESCRIPTORS   *College Students; Comparative Analysis; *Computer
                Assisted Instruction; Computer Programs; Conventional
                Instruction; Cost Effectiveness; Course Evaluation;
                *Field Studies; Programing; Statistical Analysis
IDENTIFIERS   BASIC; COBOL; Data General NOVA Minicomputer;
                Learning Resource Aided Instruction; Minicomputers

ABSTRACT
        Very little work has been done in the broad field of
computer-assisted instruction (CAI) to exploring the use of a
minicomputer as another learning resource in the instructional
process. Accordingly a cost-effective Learning Resource Aided
Instruction (LRAI) System centered around a Data General NOVA
minicomputer augmented with slide projector-audio cassette media was
designed and developed at the University of California, Santa
Barbara. A similar system was integrated into the educational program
at California Polytechnic State University and experimentally
evaluated for two courses with large enrollments. These courses were
an introduction to COBOL and an introduction to BASIC, respectively.
The evaluation procedure consisted of comparing the curricula of the
two courses taught in a traditionally-aided instruction (TAI) mode
with that taught in a LRAI mode using appropriately structured
questionnaires, common examinations, and statistical analyses. The
results of the evaluation strongly demonstrated that the performance
of students using the LRAI approach was better than those in the TAI
mode of instruction. (Author/WCM)

Field Evaluation of a Mini

Learning Resource Aided Instruction System

Emile E. Attala
California Polytechnic State University

James A. Howard
University of California at Santa Barbara

ABSTRACT

Very little work has been done in the broad field of Computer-Aided Instruction (CAI) in exploring the use of a minicomputer as simply another learning resource in the instructional process. Accordingly, a cost-effective Learning Resource Aided Instruction (LRAI) System centered around a Data General NOVA minicomputer augmented with slide projector-audio cassette media, was designed and developed at the University of California, Santa Barbara (UCSB) [1].

A similar system was integrated into the educational program at California Polytechnic State University (Cal Poly) San Luis Obispo, California and experimentally evaluated for two courses with large enrollments. These courses were CSc 100, an introduction to COBOL and CSc 110, an introduction to BASIC, respectively. The evaluation procedure consisted of comparing the curricula of the two courses taught in a traditionally-aided instruction (TAI) mode with that taught in a LRAI mode using appropriately structured questionnaires, common examinations, and statistical analyses. The results of the evaluation strongly demonstrated that the performance of students using the LRAI approach was better than the TAI mode of instruction.

I. INTRODUCTION

Over the past ten years there has been an explosive rate of growth in the types and applications of minicomputers which has created a strong impact on the computer industry as a whole. Applications, that were previously in the domain of large computers only, are now being taken over by mini's. This trend will continue because of the startling progress in electronics technology which has driven the cost of computing equipment steadily down. Also in the past the minicomputer manufacturers supplied little or no software packages to their users; today, the most effective selling point of the minicomputer manufacturer is to provide the user with a variety of software packages to help him in his particular application.

Despite the vast research endeavor in the field of computer-aided instruction (CAI), little work has been done in exploring the use of a minicomputer as simply another learning resource in the instructional process. Instead, the emphasis has been primarily on the use of the computer as the only available resource in a CAI system. Even when learning resources such as video tape and slide-projector audio cassette systems have been incorporated with the computer medium of instruction, the computer is usually allowed to have control over such resources via an appropriate hardware inter-face. One drawback of this approach is that these resources generally become subservient to the computer and the resulting system is still utilized as a CAI system rather that a Learning Resources Aided Instructional (LRAI) System. Furthermore, it is almost impossible

to configure a LRAI System with off-the-shelf learning resources if the computer is to be in control of these resources.

This dilemma can be resolved by configuring a LRAI system around a low cost minicomputer augmented with appropriate audio visual media. In this configuration the computer is viewed as simply another learning resource which the student controls in conjunction with the other resources in orchestrating his way, at his own pace, through a lesson.

With the above viewpoints in mind a LRAI system was designed and developed at UCSB. A similar system was easily integrated into the instructional program at Cal Poly and experimentally evaluated for two courses with large enrollments. These courses were CSc 100 and CSc 110 introductions to programming COBOL and BASIC, respectively. The hardware, software, courseware, and cost of these systems were described in detail in a paper presented at the 1973 ADCIS summer conference in Ann Arbor, Michigan [2].

This paper briefly reviews the hardware, software, and courseware of the Cal Poly LRAI system. The evaluation methodologies and results for the CSc 100 and CSc 110 courses that were programmed on the system are then discussed in detail. Some general considerations regarding the cost and efficiency of a LRAI system are then presented. Finally some concluding remarks delineating the advantages of LRAI systems, their place in the educational environment, and further research directions are outlined.

II. CAL POLY LRAI SYSTEM DESCRIPTION

. The LRAI system at Cal Poly is a four terminal (3 Teletypes and 1 CRT) system configured around a Data General 1220 minicomputer with 20,000 words of memory. Each terminal is augmented by a combination cassette tape recorder and 35 mm rear-screen slide projector that can easily be mounted above the terminal. Multiuser timesharing BASIC was chosen as the programming language because it was a software module available at no cost from the manufacturer, was easy to learn, and in general met all of the criteria established for a CAI language.

Another important factor in the selection of BASIC as the LRAI language is that any software developed can be easily exported to other systems because BASIC is so widely supported, particularly on minicomputers. A course module on a LRAI system consists of a set of slides, a set of audio cassettes, and a set of BASIC programs. Since BASIC is exportable, a course module can easily be implemented on any system supporting BASIC by simply augmenting the system with an off-the-shelf slide projector and audio cassette.

Several minor problems do exist with respect to exportability. BASIC, like all other programming languages, comes in a variety of dialects and is thus system dependent. Thus the BASIC programs representing a given course module will have to be modified to some extent when they are transferred to a new system. The authors experience is that this can be done with a minimum of effort.

A second consideration with respect to exportability is establishing the amount of memory required for a LRAI unit. In general,

the minicomputer versions of BASIC which can support a LRAI system occupy between 6 - 8K (16-bit words) of memory. For example the version of BASIC employed on the Cal Poly system uses 8K of memory. By proper partitioning of the subject material between the various learning resources a LRAI system unit that contains the same material as a 45 minute TAI lesson can be embedded in 2K of memory. Using the above information an empirical relation for determining the memory requirements is as follows:

$$TM = 2n + 8$$

where

TM = total memory needed in thousands of 16-bit words

n = number of terminals operating simultaneously

For example 16K of memory would be required to support four terminals as in the Cal Poly system.

The first task in preparing the courseware for a LRAI system is to establish the format for a lesson as depicted in the flowchart of Figure 1. As shown in the figure, as soon as a student signs on the system the program enters an initialization subroutine where cliche sentences used frequently in different responses are initialized. Then the program goes through the introduction subroutine which welcomes the student to the lesson and describes the rules adopted for the presentation of the lesson frames to the student. The tutoring part of the lesson then follows. Upon completion of the tutoring portion of the lesson the drill-and-practice session of

the lesson is started. This part consists of a series of questions that test the student's comprehension of the tutoring part. At the termination of the drill-and-practics session, control is either returned to the tutoring part or the lesson is terminated.

Preparation of the courseware for a LRAI system involves partitioning of the subject matter for a given course among the various learning resources comprising the system. In the case of the Cal Poly system this involved appropriate orchestration of the subject material among the slide projector, audio cassette, and minicomputer resources. The critical resource is the amount of memory available in the computer for utilization in the LRAI system. Because of this restriction a methodological approach was designed to distribute the events of a lesson among the resources of the system so that the equivalent of a 45 minute TAI lesson could fit into 2K of memory. This necessitated a highly structured approach that distributed the tutoring and drill-and-practice parts of the lesson on the audio-visual media and left in memory only the computer responses varying from one question to another. The strategy proved to be appropriate and most effective in formalizing the sequential events of a lesson to achieve an appropriate interaction between the student and the LRAI system.

III. SYSTEM EVALUATION

The evaluation phase of the LRAI system started in the Fall
of 1973 at Cal Poly and consisted of comparing the system curriculum
for COBOL and BASIC with the same curriculum taught in a TAI mode.

BASIC is taught in two courses at Cal Poly, CSc 110 and CSc 410
respectively. The thirteen students in the CSc 410 course were
put on the LRAI system, while CSc 110 was taught in a TAI mode.
Since the LRAI and the TAI samples are from two different populations
statistical evaluation methods were not used for comparing the BASIC
curriculum.

The COBOL curriculum offered a more idealized environment for
evaluation. COBOL programming attracts about 360 students per
quarter, grouped in about 12 sections. To obtain a sample that
truly represents this population, two sections (about 60 students)
were randomly selected from the twelve sections. After teaching
all sections the principles of flowcharting and some terminology
in a TAI mode, they were then given an examination. Based on the
results of the examination, the two sections were divided in four
strata and a sample of three students were randomly selected from
each stratum. So all in all, 12 students took the CAI COBOL course
and were grouped in four groups, G1, G2, G3, and G4 representing
the "D-students", the "C-students", the "B-students", and the
"A-students" respectively.

Between the BASIC-LRAI students and the COBOL-LRAI students more
than 400 student-hours were logged on the system during the Fall
quarter, 1973. During this period no major delays or shut-downs

were experienced due to system malfunctioning.

No conventional classes were conducted for the two LRAI groups Instead, the instructor was available by appointment to a student or a group of students to answer questions, and to facilitate the scheduling and operation of the LRAI room.

The BASIC and COBOL courseware were evaluated after each LRAI session and at the termination of the courses. After each session when the aspects which the student liked or disliked would be fresh in him mind, the student was asked to answer the following questions:

1. What aspects of this unit did you like most, or were particularly effective?

2. How could this unit be improved? Please be as specific as possible.

The results of the unit evaluation were used to detect and correct any errors in a unit. Furthermore, the results allowed successor units to be modified if they had been effected by errors in predecessor units.

The questionnaire utilized to evaluate the whole system at the end of the course is shown in Figure 2. The letters A, B, C, D, E and F appearing on the form are used to facilitate the tabulation and plotting of the students' responses.

Table 1 shows the responses of the 12 students of CSc 410 who were taught BASIC in a LRAI mode. Interesting observations which can be deduced from their responses are as follows:

(a) Two students felt that LR'T would be a detriment in some courses; however, they would recommend it to a friend.

(b) No one was annoyed with the repetitive use of multiple choice questions.

(c) Only three students were annoyed with the stereotyped responses they were getting from the computer.

(d) Surprisingly enough, six students enjoyed loading paper tape and four more were not distracted or annoyed by it.

(e) Eight students enjoyed manually handling the different learning resources.

(f) Unanimously, the class agreed that a typical unit was about right in length.

Eleven out of twelve students returned their questionnaires from the COBOL LRAI section. Table 2 summarizes their combined responses according to their group.

Again, some interesting deductions from their responses are as follows:

(a) Only one C-student felt he would have learned more from TAI, while two A-students felt it would have made no difference.

(b) No one was annoyed with the repetitive use of multiple choice questions and only two C-students were annoyed with the stereotyped responses from the computer.

(c) Two C-students felt annoyed with loading paper tapes.

(d) Only one B-student felt that a typical unit was too long; the rest felt it was about right.

The overall results of the questionnaire evaluation indicate that the LRAI approach was well accepted by both the COBOL and BASIC LRAI students.

Figure 3 shows detailed plots of the grade distributions for the LRAI system and TAI COBOL sections. The results of the examination (Figure 3a) which was administered prior to selecting the LRAI sample shows that there are 22 TAI students separating CAI Group G3 and G4, 6 TAI students separating G2 from G3, and only one TAI student separating G1 from G2. (Recall that the LRAI COBOL sample was divided into four groups: G1 represented the "D-students", G2 the "C-students", G3 the "B-students", and G4 the "A-students".) A study of the homework, final examination, and total grade distributions of Figures 3b,c and d indicates the following:

(a) All but one LRAI stduent received full credit for their homework, and only two TAI students could achieve the same result (Figure 3b).

(b) On the final examination, eight out of the twelve CAI students scored above 80%, and only six out of the forty-six TAI students could achieve the same result (Figure 3c).

(c) Totaling homework, final examination, and mid-term results, nine out of the twelve LRAI students scored above 80%, and

only 13 out of the 46 TAI students could achieve the
same result (Figure 3d).

Similar results were achieved by the BASIC group.

A null hypothesis test [3] was conducted only on the COBOL
sections because the LRAI sample was selected from the same popu-
lation. The null hypothesis that the mean score of the LRAI group
and the mean score of the TAI group are the same was tested against
the alternative that the mean score of the LRAI group is greater
than the mean score of the TAI group. The following assumptions
were made for the null hypothesis test:

1. The sampling came from normal populations. This assumption,
    which is fairly valid in this kind of sample, is not at all
    critical when used with the t-test since the t-test is
    quite robust without this assumption.

2. The variances of the two populations are the same.

The results of the null test showed that the mean score of the
final examination for the LRAI group was significantly higher
than the mean score for the TAI group. The level of significance
was less than .005. The calculated value of the test statistic
($t = 3.652$) which, when compared with the percentage points of a
t-distribution with 56 degrees of freedom, is very significant.

In summary, the responses ot the students to the evaluation
questionnaire demonstrated that the LRAI system is a successful
teaching tool. Their performances during the quarter and in the
final examination supported, without a shadow of doubt, the claim

that when properly orchestrated and administered this mode of instruc-
tion becomes a powerful vehicle in the hands of the instructor.

IV. LRAI COST CONSIDERATIONS

The most fundamental principle of economics postulate that
the only justification for any training device or medium is its
cost effectiveness. CAI, like any other important operation or
service, cannot be conducted successfully without a sound
financial base. Several assumptions and attempts are available in
the literature that compare the economics of CAI versus the
economics of TAI [4]. There are also several different approaches
along which CAI cost is presently evolving [5]. One approach
is for a single, powerful timesharing system to serve several
thousand terminals and cover a broad geographical region to bring
CAI cost to the level of TAI as PLATO at the University of Illinois.
Another approach is for a mini-system (4 to 32 terminals) to
serve a single location thus eliminating the tremendous communi-
cation problem the first approach will have to face. The latter
approach is the one taken in this research.

It is important to point out that the authors do not advocate
the total replacement of the TAI system of instruction by a CAI
system. It should be clearly recognized that the LRAI system is
designed to help the instructor and redefines his role vis-a vis
his students. That is why it is more meaningful to postulate
cost formulas that combine the two modes of instruction and draw

equal cost curves for different TAI-LRAI combinations. Equal cost curves will be clearly defined from the following example which was derived from true data assembled at Cal Poly.

At Cal Poly approximately 12 sections of CSc 100 are taught every quarter in a TAI mode. Each section has about 30 students (i.e., the total number of students processed per quarter is 360).

The total number of students (TNS) that are taught CSc 100 at Cal Poly during a five year period is

TNS = (5 years)(3 quarters/year)(12 sections/quarter)
      (30 students/section)

    = 5,400 students.

Since CSc 100 is a 2 unit course (about 20 hours of TAI) then the total number of hours (TNH) needed is

TNH = (20)(5400) = 108,000 hours.

The cost of teaching 108,000 hours in a 100% TAI mode is $120,000. This figure was derived by calculating the number of full-time instructors needed to teach 12 sections of CSc 100 per quarter (2 instructors) and multiplying their combined annual salaries by five. The annual salary is based on the salary of an Assistant Professor, step 3, working three quarters per year.

Assume that a 32 terminal LRAI system (i.e., an HP 2000 F or PDP 11/45 time sharing systems) with a life span of five years existed at Cal Poly. The cost of such a system excluding terminals but including CPU, memory, disk, 9 track magnetic tape and so forth is in the order of $100,000. An additional $100,000 must be added

to this base cost for terminals, audio-visual equipment, and system maintenance and support cost for the assumed 5 year period. This brings the total LRAI system cost to $200,000.

To be able to derive the cost of teaching the same number of students in CSc 100 in a 100% LRAI mode, the following assumptions and calculations are made.

Life Span of System = (5 years)(30 weeks/year)(6 days/week)
(12 hours/day)(32 terminals)

= 345,600 hours

The cost of the LRAI system per hour is

$$\text{Cost-per-hour} = \frac{\$200,000}{345,600} = \$.58$$

To process the same 5,400 students assume each student will need 20 hours on the system similar to the 20 hours needed in the classroom, so that the total cost will be

5,400 × 20 × .58 = $62,640

An equal cost curve can be derived from the relation

%TAI ($120,000) + %LRAI (62,640) = $120,000

Table 3 shows several solutions to the above expression for various percentiles of TAI and Figure 4 shows the corresponding equal cost curve. From the preceding discussion it is evident that for a LRAI system which is amortized over five years one needs only to reduce his manpower by 51% to achieve equal cost. It is also evident that after the 5 year amotization period the cost

per contact hour on the LRAI system will become very economical.

If efficiency is defined as the number of students taught per unit cost, one can easily compare TAI efficiency versus LRAI efficiency as follows:

$$\text{Efficiency} = \frac{\text{Total Number of Hours}}{\text{Total Cost}}$$

$$\text{TAI Efficiency} = \frac{108,000}{\$120,000} = .90 \text{ Hours/Dollar}$$

$$\text{LRAI Efficiency} = \frac{162,000}{\$62,640} = 2.59 \text{ Hours/Dollar}$$

which could be translated as follows:

"Assuming equal teaching effectiveness one can process three times the number of students using a mini LRAI system over TAI per unit cost."

The authors do not subscribe to this kind of philosophy. As has been stated several times, the teacher is an integral part of the LRAI system. It is mainly designed to provide him with a powerful tool to use when he sees fit. What makes sense, however, is to reduce TAI manpower by a certain percentage and replace it with one or more LRAI system to achieve an optimal system of instruction. Some institutions might even find a $200,000 initial investment on a system as the one described in the above example out of their reach. The advantage that the minicomputer general systems available on the market today offer is the possibility to start with a simplistic LRAI system configuration to experiment with it before expanding it to the $200,000 system. For example at Cal Poly the LRAI system initial cost was $15,000 and that included the NOVA CPU, 12K of

memory, 2 teletypes enhanced with two audio/visual units. This

can be easily increased to 32K of memory, 8 stations, 3 cassettes

drives for a total cost of $40,000 prorated at about $.40/contact

hour. This flexibility is quite an economical advantage especially

for institutions which would like to experiment and gather enough

meaningful data before making a drastic switch in their mode of

instruction.

V. CONCLUDING REMARKS

A Learning Resource Aided Instruction System utilizing a

minicomputer with 16K of memory and slide-audio cassette media has

been designed and evaluated. This prototype system supports 4

stations; each user requires 2K memory and the system software

(e.g., time-sharing BASIC) acquires the remainder of memory. Two

undergraduate courses with large enrollments, programming BASIC

and COBOL respectively have been implemented on the system. These

curricular materials have been evaluated during the Fall of 1973

at Cal Poly in actual COBOL and BASIC courses.

The responses of the students to the evaluation questionnaires

and the results of the statistical analysis performed demonstrated

that the LRAI system is a successful teaching tool that enhances

the role of the teacher vis-a-vis his students. The cost-analysis

of the system demonstrated that it could be a cost-effective stand-

alone system that even a small institution could afford and that

the system could be easily integrated in the instructional process

of any institution. Also the software modularity of a LRAI system makes its exportability easily accomplished hence it can be implemented on any system which supports BASIC.

The LRAI system, on one hand being a general purpose system, can be used for more than one application. On the other hand, as a LRAI system, it is an ideal tool for innovative cost-effective educational research. The effect of adding new audio/visual aids to enhance teaching effectiveness can easily be investigated on a LRAI system. For example microfilm and/or microfiche viewers could be part of a LRAI station to improve comprehension of the material being presented. A new device called the Cue/See [6] will be soon tested with the LRAI system at UCSB. The advantage of the Cue/See device is the flexibility it gives by separating the visual part from the audio part on a film strip. Consequently it makes no difference how long the visual presentation is discussed, only one frame might be needed if there is no motion involved.

Finally, the enthusiastic reaction that this research created and the endorsements that mini-LRAI systems are getting in technical conferences strongly suggest that this kind of cost-effective innovative research should be encouraged and publicized.

REFERENCES

1. "A Learning Resource Aided Instruction System Using a
    Mini Computer", Emile E. Attala, Ph.D. Dissertation,
    University of California at Santa Barbara, 1974.

2. "A Learning Resource Aided Instruction System Using a
    NOVA Mini Computer", Emile E. Attala, James A. Howard,
    ADCIS Summer Conference, University of Michigan, Ann Arbor,
    Michigan, August 1973.

3. Elementary Statistics, R. Johnson, Duxbury Press,
    North Scituate, Massachusetts.

4. "CAI Versus TAI: Economics", F. F. Kopstein, J. R. Seidel,
    AV Communication Review, Vol. 16, No. 2, Summer 1968.

5. "Estimated Costs of CAI for Compensatory Education in
    Urban Areas", D. Januson, P. Suppes, and C. Buller,
    Educational Technology, Sept. 1970.

6. "The Cue/See", Beseler, Photo & Sound Company, 1974-1975
   Audio-Visual Catalog, p. 158.
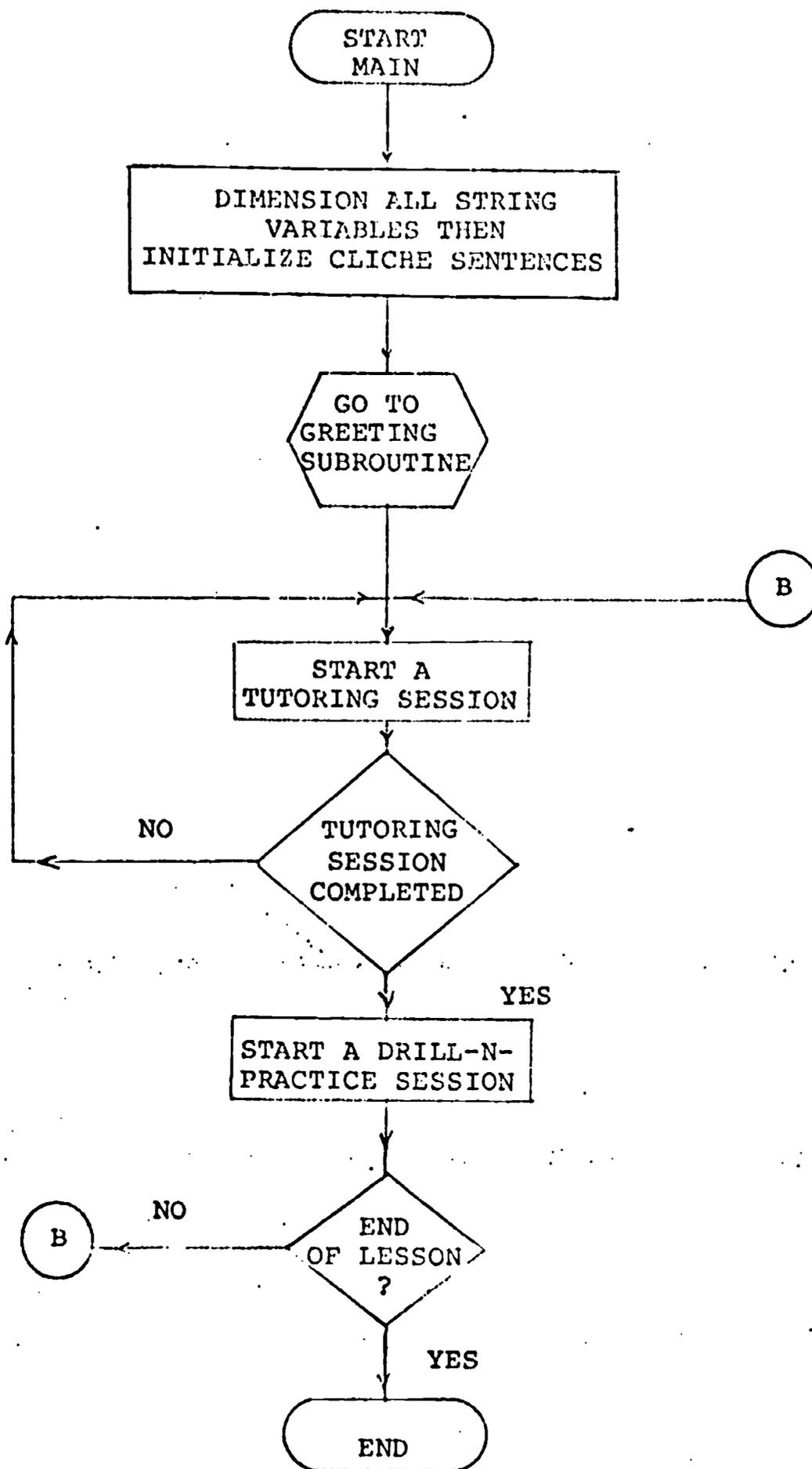
Figure 1 - Flowchart for a LRAI Tutorial Unit

LRAI QUESTIONNAIRE

The purpose of this survey is to help improve the LRAI system so that it will better facilitate students' learning. Your honest reactions will be of great help.

1. Did you enjoy the LRAI mode of instruction? circle 1 - 5.

              (A) (B) (C) (D) (E)

    Enjoyed it   Didn't enjoy it
    a great deal 5   4   3   2   1 at all.

2. Did you feel you learned more from LRAI than you probably would have learned from TAI over this same course material?

   (A) ___ Probably learned more from LRAI.

   (B) ___ Probably would have learned more from TAI.

   (C) ___ It probably wouldn't make any difference.

   (D) ___ I don't know, have no basis for judging the difference, etc.

3. Would you take another course using LRAI if it were offered?

   (A) ___ LRAI would be a positive attribute to any course.

   (B) ___ LRAI would be a positive attribute of some courses.

   (C) ___ LRAI would make no difference one way or the other.

   (D) ___ LRAI would be a detriment in some courses.

   (E) ___ LRAI would be a detriment in all courses.

4. Would you recommend that a friend with interests similar to yours take this course in the LRAI format?

   (A) ___ Yes

   (B) ___ No

The following questions identify some specific characteristics of LRAI as used in this course. Please check the appropriate responses.

		(A)	(B)	(C)
		Annoying, distracting, interfered with learning the material.	Wasn't distracting, or didn't interfere with learning.	Enjoyed it.
5.	Repetitive use of multiple choice questions			
6.	Stereotyped responses of computer to answers			
7.	You load the paper tape			
8.	You manually handle the different learning resources. (you cue slide, turn recorder on & off, etc.)			

(A)   (B)   (C)

9. The typical unit was: ___ too long ___ about right ___ too short

10. Overall, how would you grade this course? A B C D F

Figure 2 - Questionnaire for evaluation of LRAI system
BASIC and COBOL courses.

BASIC

QUESTION	A	B	C	D	E	F
1	3	7	2	1	0	
2	6	5	1	1	0	
3	4	7	0	2		
4	11	2				
5	0	7	6			
6	3	8	2			
7	3	4	6			
8	0	5	8			
9	0	13	0	0		
10	3	6	3	0	0	

BASIC LRAI Group Responses to Questionnaire of Figure 2

TABLE 1

TAELE 2

QUESTION NUMBER	A Group 1	2	3	4	T	B Group 1	2	3	4	T	C Group 1	2	3	4	T	D Group 1	2	3	4	T	E Group 1	2	3	4	T	F Group 1	2	3	4	T
1	2	3	3	3	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
2	2	2	3	1	8	0	1	0	0	1	0	0	0	2	2	0	0	0	0	0										
3	1	2	0	0	3	1	1	3	3	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
4	2	3	3	3	11	0	0	0	0	0																				
5	0	0	0	0	0	1	1	2	1	5	1	2	1	2	6															
6	0	2	0	0	2	2	1	3	3	9	0	0	0	0	0															
7	0	2	0	0	2	2	1	2	3	8	0	0	1	0	1															
8	0	0	0	0	0	2	2	3	2	9	0	1	0	1	2															
9	0	0	1	0	1	2	2	2	3	9	0	0	0	0	0															
10	2	2	1	2	7	0	0	2	1	3	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0

COBOL LRAI Cumulative Responses to Questionnaire

of Figure 2
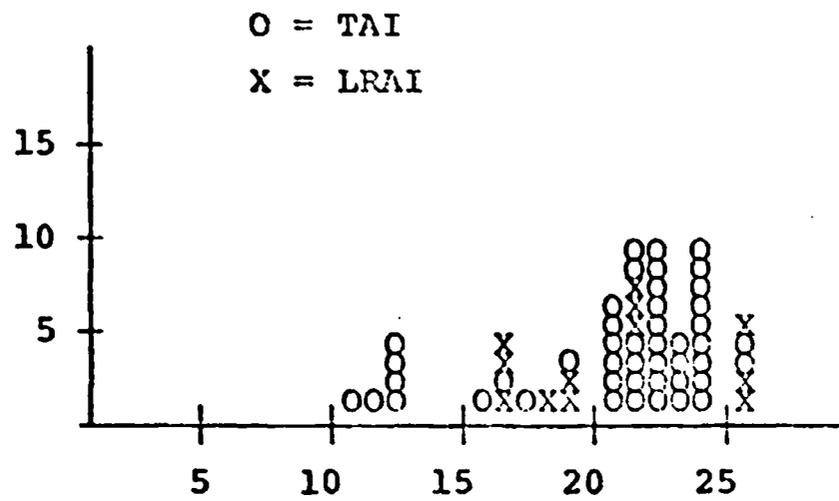
3a   Midterm Exam Score before selecting LRAI
   Sample.
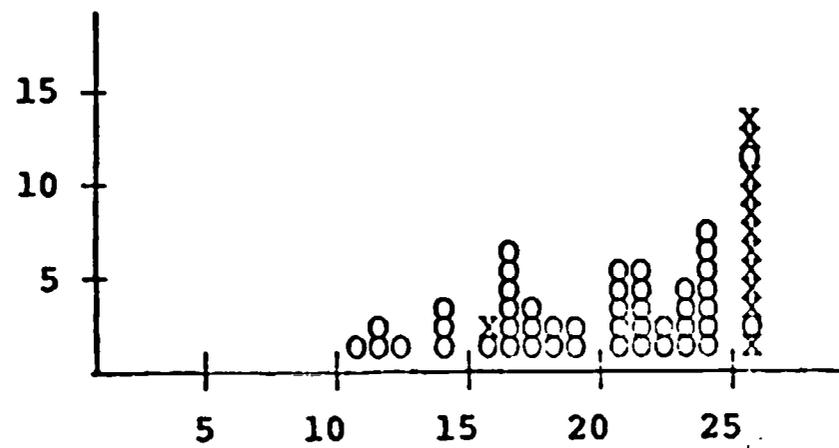
3b   Homework grades

Figure 3

Grade distributions for LRAI and TAI COBOL sections.
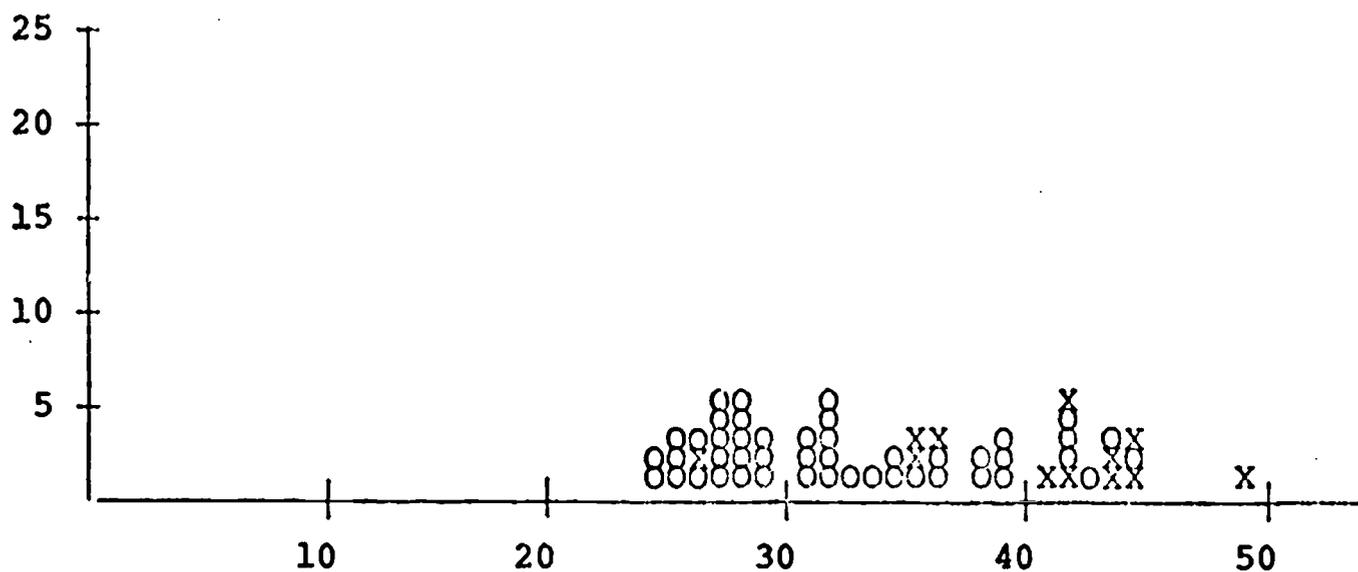
3c   Final Exam Scores
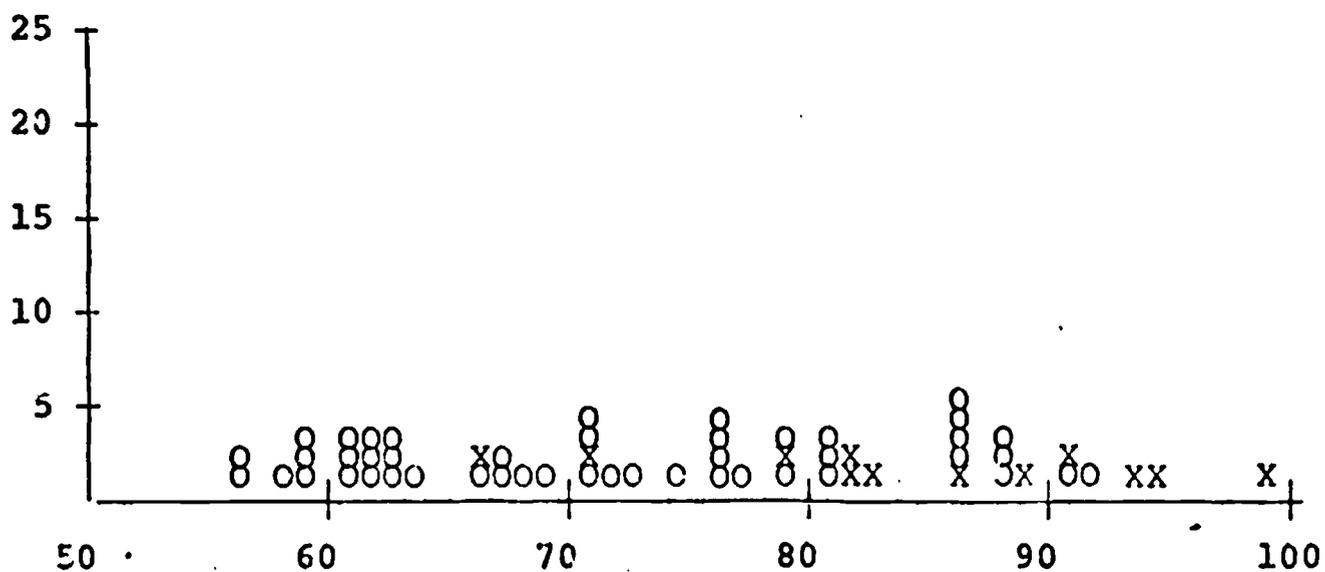
3d   Total Grade Distribution

Figure 3 (con't)

Grade distributions for LRAI and TAI COBOL sections.

$$LRAI = \frac{120,000 - 120,000 \text{ TAI}}{62,640}$$

| TAI %	LRAI %
100	0
90	19.2
80	38.3
70	57.5
60	76.6
50	95.7
51	100.0
40	114.9
30	134.1
20	153.3
10	175.6
0	191.6

TABLE 3

Percentiles TAI versus LRAI
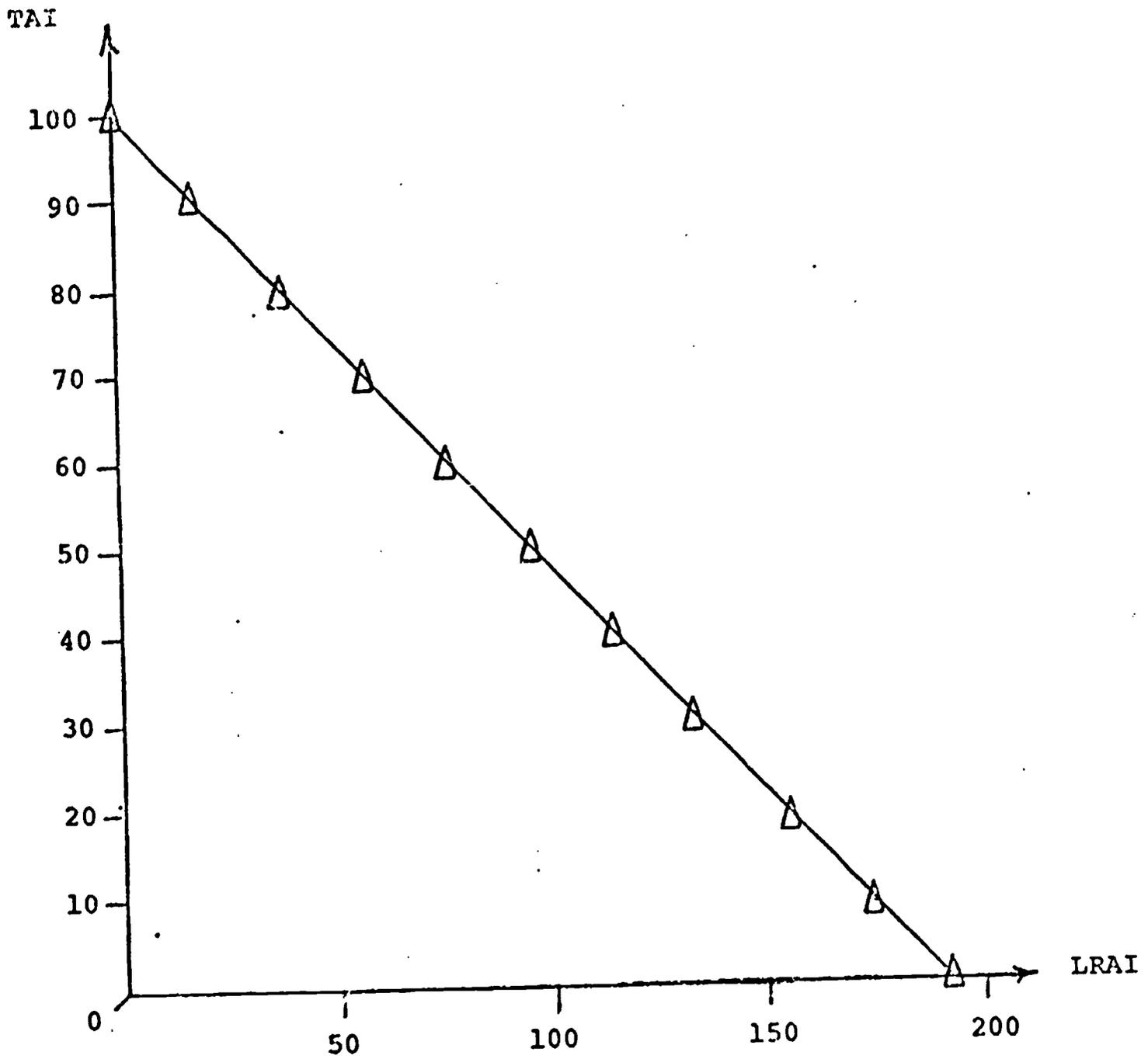
Figure 4

Equal Cost Curve